SOME THOUGHTS ON OUR NATIONAL SPACE PROGRAM

BY ADDISON M. ROTHROCK, ASSOCIATE DIRECTOR OFFICE OF PLANS

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

PRESENTED TO AIAA SPACE FLIGHT TESTING CONFERENCE

MARCH 18-20, COCOA BEACH, FLORIDA

-INTRODUCTION-

I WANT TO DISCUSS WITH YOU THE STATUS OF OUR NATIONAL SPACE PROGRAM - TO DISCUSS THOSE THINGS WE PLANNED TO ACCOMPLISH THAT WE HAVE ACCOMPLISHED, AND THOSE THINGS WE PLANNED TO ACCOMPLISH THAT WE HAVE NOT ACCOMPLISHED. I WANT TO TOUCH BRIEFLY, ON THE KIND OF INDUSTRY WE ARE CREATING, ON ITS RELATION TO THE ECONOMY OF THE NATION AS A WHOLE AND ITS DEMANDS ON OUR EDUCATIONAL SYSTEMS. I WILL BRING TO YOUR ATTENTION, ALTHOUGH I KNOW YOU ARE ALREADY AWARE OF THEM, CERTAIN QUESTIONS WE MUST ANSWER IN DECIDING ON OUR FUTURE PROGRAMS.

I WANT TO EMPHASIZE THAT THE OPINIONS I WILL EXPRESS ARE MY PERSONAL OPINIONS, AND THEY ARE, OF COURSE, SUBJECT TO ARGUMENT; BUT I THINK IT WELL THAT THOSE OF US HAVING TO DO WITH THE LONG RANGE PLANNING OF OUR SPACE PROGRAM INFORM YOU OF OUR OPINIONS.

ONE CAN SUMMARIZE OUR NATIONAL SPACE OBJECTIVES AS:

1. EXPLORATION IN SPACE TO GAIN SCIENTIFIC AND ENGINEERING KNOWLEDGE.
2. APPLICATION OF THIS KNOWLEDGE TO THE GENERAL WELFARE OF MAN AND TO THE PROTECTION OF OUR NATIONAL INTERESTS.

TO FULLY EXPLORE AND UTILIZE SPACE, REGARDLESS OF THE PURPOSE OF THIS EXPLORATION OR UTILIZATION, SPACE FLIGHT SYSTEMS

ARE REQUIRED THAT PROVIDE:

1. MANEUVERABILITY OF SPACECRAFT IN SPACE
2. RENDEZVOUS AND DOCKING OF SPACECRAFT WITH OTHER SPACECRAFT WITH OR WITHOUT ASSISTANCE BETWEEN THE SPACECRAFT.
3. REPLENISHMENT OF SPACECRAFT AND REPLACEMENT OF CREWS IN SPACE.
4. PROVISIONS FOR SPACECRAFT, ON RETURN TO EARTH, TO LAND AT A SITE SELECTED BY THE PILOT OF THE SPACECRAFT (A SITE APPROXIMATING A NORMAL AIRFIELD).
5. FAST LAUNCH REACTION TIME; THAT IS READINESS TO LAUNCH A SYSTEM AT ANY TIME WITH A FEW MINUTES NOTICE.
6. RE-USE OF LAUNCH VEHICLES AND SPACECRAFT (IN THE SAME GENERAL SENSE AS PRESENT DAY AIRCRAFT).
7. HIGH FREQUENCY OF OPERATIONS.
8. LOW COST OF OPERATIONS.

THESE ARE THE REQUIREMENTS OF ANY BROADLY USED TRANSPORTATION SYSTEM, AND, AS IN THE EARLY STAGE OF THE DEVELOPMENT OF AND EXPLORATION WITH OTHER TRANSPORTATION SYSTEMS, LIMITATIONS ARE CURRENTLY PERMITTED IN SPACE CRAFT THAT WILL NOT BE TOLERATED AS THE DEVELOPMENT PROCEEDS.

IN GOING INTO SPACE, THERE WERE NO NEW PRINCIPLES INVOLVED. IT WAS ESSENTIALLY A QUESTION OF DEVELOPING SPACE SYSTEMS UTILIZING KNOWN PRINCIPLES IN MECHANICS, CHEMISTRY, AND ELECTRONICS, AND OF DECIDING ON THE MAGNITUDE OF THE SPACE EFFORT. FROM THIS STANDPOINT, THE SITUATION WAS QUITE DIFFERENT FROM THE EXPLOITATION, SAY, OF NUCLEAR ENERGY IN WHICH PRINCIPLES HAD TO BE EXEMPLIFIED

ON LARGE SCALE THAT HERETOFORE HAD NOT GONE BEYOND BASIC RESEARCH IN THE LABORATORIES.

ALTHOUGH NO NEW SCIENTIFIC PRINCIPLES WERE INVOLVED, THERE WAS MUCH NEW ENGINEERING KNOWLEDGE REQUIRED FOR SUCCESSFUL OPERATION IN THIS HIGHERTO UNEXPLORED ENVIRONMENT. AND FOR THIS REASON AN EXTENSIVE SUPPORTING PROGRAM OF APPLIED RESEARCH WAS AND CONTINUES TO BE NECESSARY.

THE NEW ENGINEERING KNOWLEDGE NEEDED APPLIES PARTICULARLY TO THE LAUNCH VEHICLES AND SPACECRAFT. HERE A BASICALLY NEW TECHNIQUE WAS REQUIRED - THAT OF DEVELOPING HIGHLY COMPLICATED DEVICES OF GREAT SIZE THAT COULD NOT BE TESTED UNDER FLIGHT CONDITIONS PRIOR TO FLIGHT AND EXCEPT IN LIMITED CASES COULD NOT BE EXAMINED AFTER FLIGHT REGARDLESS OF WHETHER THE FLIGHT SUCCEEDED OR FAILED.

OF THE MORE THAN A HUNDRED SPACECRAFT THAT THE UNITED STATES HAS LAUNCHED INTO EARTH OR SOLAR ORBIT, ALL BUT THE FIVE MERCURY CRAFT HAVE BEEN IN THE FIELD OF SCIENCE, OR IN THE FIELDS OF APPLICATIONS - EXPLORING THE ENVIRONS BETWEEN THE EARTH AND THE MOON, EXPLORING THE SUN, EXPLORING SPACE BEYOND OUR SOLAR SYSTEM, AND EXPLORING THE EARTH ITSELF; OR OF APPLICATIONS IN COMMUNICATIONS, METEOROLOGY, NAVIGATION, GEODETIC SURVEY AND SPECIFICALLY MILITARY FIELDS.

THE INSTRUMENTS IN THESE SPACECRAFT TO PERFORM THE FUNCTIONS FOR WHICH THESE FLIGHTS WERE MADE, HAVE FOR MUCH OF THE PROGRAM PROVED TO BE WELL WITHIN THE STATE-OF-THE-ART. THIS IS EXEMPLIFIED IN THE DISCOVERY OF THE VAN ALLEN BELT WITH THE FIRST UNITED STATES SPACE FLIGHT, EXPLORER I, OF THE IMMEDIATE SUITABILITY OF

OF TIROS WEATHER INFORMATION FOR ASSISTANCE IN OUR WEATHER FORECASTING, THE IMMEDIATE USE OF TELSTAR FOR TRANSOCEANIC TV, THE SUCCESS OF MARINER II.

ONE CANNOT OVEREMPHASIZE THE PART RESEARCH IN SOLID STATE PHYSICS HAS PLAYED IN BRINGING OUR INSTRUMENT STATE-OF-THE-ART TO ITS CURRENT VERY EFFECTIVE LEVEL.

-SPACE TRAVEL-

TRAVEL IN SPACE IS AS DIFFERENT FROM TRAVEL IN THE AIR AS TRAVEL IN THE AIR IS FROM TRAVEL ON LAND OR SEA. THIS SHOULD BE WELL REALIZED.

OUR LONGEST COMMERCIAL AIR FLIGHTS ARE A FIFTH TO A QUARTER WAY AROUND THE GLOBE - THE DISTANCE FROM LOS ANGELES TO LONDON, FROM SEATTLE TO TOKYO. AIR FLIGHTS TO 12,000 MILES HAVE BEEN ACHIEVED. BUT IN SPACE, WALTER SCHIRRA IN HIS FLIGHT IN THE MERCURY SPACECRAFT TRAVELED 150,000 MILES, CIRCUMNAVIGATING THE WORLD SIX TIMES. GEMINI, OUR TWO MANNED SPACECRAFT, WILL TRAVEL OVER THREE MILLION MILES IN A FLIGHT OF A WEEK'S DURATION. VANGUARD, THE SECOND SPACECRAFT LAUNCHED BY THE UNITED STATES, HAS TO DATE TRAVELED 750 MILLION MILES AND WE ARE STILL IN TOUCH WITH IT.

AN AIRPLANE CAN REACH AN ALTITUDE OF ABOUT 12 MILES. THE HYBRID AIR AND SPACE RESEARCH CRAFT, THE X-15, HAS REACHED A DISTANCE FROM THE EARTH OF 50 MILES, BUT THE MARINER II SPACECRAFT WAS BY MID JANUARY 60,000,000 MILES FROM THE EARTH.

THE LONGEST TIME AN AIRPLANE HAS STAYED ALOFT (AND THIS WITH REFUELING) IS A MONTH OR SO. THE VANGUARD SPACECRAFT HAS BEEN ALOFT FIVE YEARS AND ITS TOTAL TIME WILL BE MEASURED IN HUNDREDS OF YEARS.

A SPACECRAFT LAUNCHED INTO A LOW EARTH ORBIT SUCH THAT IT FLIES OVER NEW YORK WILL ALSO WITHIN 24 HOURS FLY OVER OR WITHIN A FEW HUNDRED MILES OF MADRID, ROME, STALINGRAD, ANKARA, PEKING,

TOKYO, BUENOS AIRES, BRAZILLIA, HAVANA, AND IN FACT OVER ALL CITIES AND NATIONS BETWEEN THE NORTHERN AND SOUTHERN 40TH PARALLELS.[1]

MANEUVERABILITY OF SPACECRAFT IS ESSENTIALLY DIFFERENT, AND FROM CERTAIN VIEWPOINTS MORE LIMITED, THAN MANEUVERABILITY OF LAND, SEA, OR AIRCRAFT. IF THE SPEED OF THE SPACECRAFT IS INCREASED OR DECREASED THE CRAFT CHANGES ORBIT; IT DOES NOT DIVE OR CLIMB IN THE SENSE OF AN AIRPLANE. TO CHANGE THE INCLINATION OF A (LOW ALTITUDE) EARTH ORBITING SPACECRAFT SIXTY DEGREES, THE PROPELLANT REQUIRED IS MANY TIMES THE WEIGHT OF THE CRAFT. WE WILL NOT MANEUVER SPACECRAFT IN THE SENSE WE MANEUVER AIR, LAND, OR SEACRAFT.

BUT SO WE DO NOT UNDERESTIMATE THE CAPABILITIES OF SPACECRAFT, IT IS WELL TO POINT OUT THAT SPACECRAFT OF THE UNITED STATES AND OF RUSSIA HAVE FLOWN OR ARE FLYING OVER EVERY NATION ON EARTH. NO PERMISSION WAS SOUGHT, NONE WAS EXPRESSLY GIVEN, AND NOT A PROTEST HAS BEEN REGISTERED. AND, IN FACT, SPACE FLIGHT IN EARTH ORBIT IS IMPOSSIBLE WITHOUT THE CRAFT FLYING OVER MANY NATIONS. IT APPEARS TO BE EVOLVING THAT SAILING IN THE HIGH SEAS OF SPACE IS ANALOGOUS TO SAILING ON THE HIGH SEAS OF THE EARTH'S SURFACE.

[1]ASSUMING A 40 DEGREE ORBITAL INCLINATION ANGLE. AN INCLINATION OF 60 DEGREES COVERS THE MAJOR CITIES OF THE WORLD.

-CURRENT STATUS OF OUR PROGRAM-

I THINK OUR MAJOR ACCOMPLISHMENT IN THESE FIRST YEARS OF SPACE ACTIVITIES HAS BEEN IN LEARNING THE TECHNIQUES REQUIRED TO ACHIEVE RELIABILITY IN SPACE, TO SUCCEED IN HAVING THE SPACECRAFT ACCOMPLISH THE OBJECTIVE FOR WHICH IT WAS SENT ALOFT. THIS IS SHOWN IN THE INCREASE IN SUCCESSFUL FLIGHTS - AN INCREASE IN PERCENTAGE OF SUCCESSES AS WELL AS IN NUMBER OF SUCCESSES. TO RECAP:

YEAR	NUMBER OF LAUNCH	NUMBER SUCCESSFUL	PROPORTION OF SUCCESSES
1958	13	5	36%
1959	17	10	59%
1960	28	16	57%
1961	47	35	79%
1962	65	54	83%
TOTAL	170	119	

WE HAVE INCREASED OUR ANNUAL NUMBER OF SUCCESSFUL LAUNCHES FIVE FOLD AND BROUGHT OUR SUCCESS RATE FROM 35% TO 85%. WE HAVE LEARNED MUCH ON THIS BUSINESS OF DEVELOPING HIGHLY COMPLICATED DEVICES OF GREAT SIZE THAT PRIOR TO FLIGHT CANNOT BE TESTED UNDER FLIGHT CONDITIONS. WE CAN SUM THE RECORD MORE DRAMATICALLY BY LISTING:

MERCURY 5 SUCCESSES IN 5 TRIES

TIROS 6 SUCCESSES IN 6 TRIES

OSO 1 SUCCESS IN 1 TRY

SATURN FIRST STAGE 3 SUCCESSES IN 3 TRIES

TELSTAR AND RELAY 2 SUCCESSES IN 2 TRIES

MARINER II 1 SUCCESS IN 1 TRY

THERE IS, OF COURSE, MORE TO BE LEARNED, AND WE CANNOT YET GUARANTEE SUCCESS ON ANY GIVEN FLIGHT. THERE ARE AREAS IN WHICH WE HAVE NOT BEEN SUCCESSFUL - THE RANGER PROGRAM, THE CENTAUR, THE SYNCOM FLIGHT. SYNCOM WAS OUR FIRST ATTEMPT TO PLACE A CRAFT IN A 24 HOUR ORBIT. SYNCOM WAS LOST AFTER FIRING THE FINAL ROCKET STAGE; AND THE INSTRUMENTATION IN THE CRAFT SO FAR HAS NOT PERFORMED.

THE MANNER IN WHICH SYNCOM WAS SUBSEQUENTLY FOUND IS A TRIBUTE TO THE MEN WORKING ON THE JOB AND AN EXAMPLE OF THE PRECISION TO WHICH WE CAN WORK IN THIS NEW MEDIUM. AFTER LOSING CONTACT WITH THE CRAFT, THE MEN AT GODDARD LISTED WHAT THEY THOUGHT WERE THE MOST PROBABLE FAILURES AND COMPUTED THE ORBITS THAT WOULD RESULT FROM THESE FAILURES SEPARATELY OR IN COMBINATIONS. BECAUSE OF THE CORRECTNESS OF THEIR ANALYSIS AND BECAUSE OF THE EXACTNESS OF NEWTONIAN MECHANICS, SYNCOM WAS LOCATED IN AN ORBIT CLOSE TO THAT PLANNED.

THERE ARE TWO SPECIFIC AREAS IN WHICH WE HAVE NOT REACHED THE SUCCESS WE REQUIRE: (1) IN OUR ABILITY TO ESTIMATE THE DATES ON WHICH, THAT IS THE TIME IN WHICH, WE WILL ACHIEVE OUR OBJECTIVES AND (2) IN ESTIMATING THE COST OF THESE ACHIEVEMENTS. THESE LACKS ARE NOT A REFLECTION ON TECHNICAL ABILITIES BUT REFLECT RATHER A NEED FOR ADDITIONAL EXPERIENCE.

INVOLVED HERE IS THE MATTER OF ESTIMATING HOW LONG IT WILL TAKE AND HOW MUCH IT WILL COST TO DO SOMETHING WE HAVE NOT DONE BEFORE. IN ESTIMATING THE TIME REQUIRED TO COMPLETE A JOB, WE

USE THE PERT[2] SYSTEM, A SYSTEM CONSISTING OF BREADING THE JOB INTO SUFFICIENTLY SMALL INCREMENTS SO THAT WE CAN MAKE A REASONABLE ESTIMATE OF THE TIME REQUIRED TO COMPLETE EACH INCREMENT. THE INCREMENTS ARE THEN ARRANGED IN THE REQUIRED TIME SEQUENCE AND THE TOTAL TIME NEEDED IS ESTIMATED. IN PRACTICE TWO THINGS HAPPEN, SOME PROBLEMS WE DID NOT FORESEE OCCUR AND SOME OF THE INCREMENTS TAKE LONGER TO SOLVE THAN ESTIMATED. I DO NOT KNOW HOW TO OVERCOME THIS DIFFICULTY. IT IS INHERENT IN OUR TYPE OF WORK. AS TIME GOES ON, THE SITUATION WILL IMPROVE, BUT I DO NOT THINK THE STRETCH-OUTS - THE APPARENT DELAYS - WILL EVER BE ENTIRELY ELIMINATED; AND IF IN FACT THEY ARE ELIMINATED, I AM INCLINED TO BELIEVE WE ARE NOT SUFFICIENTLY DARING IN OUR UNDERTAKINGS.

INCREASED TIMES INEVITABLY MEAN INCREASED MANHOURS IN THE DELAYING CATEGORIES WITH THE ACCOMPANYING INCREASE IN COSTS. MEANS MUST BE PROVIDED FOR MORE ADEQUATE COST ESTIMATES SO THAT MAJOR BUDGETARY READJUSTMENTS AND PROGRAM CHANGES WILL NOT BE REQUIRED.

WHILE BUDGETS ARE INCREASING, MONETARY OVERRUNS CAN BE MANAGED WITHOUT PROGRAM STRETCH-OUTS OR PROGRAM CANCELLATION. AND, IN ADDITION, NEW PROGRAMS CAN BE STARTED. BUT WITHOUT ANNUAL INCREASES ACCURATE COST ESTIMATING BECOMES OF HIGHEST IMPORTANCE. FROM THIS STANDPOINT IT IS WELL TO EXAMINE THE HISTORY OF OUR SPACE BUDGETS FROM A 'RATE OF INCREASE' STANDPOINT. IF MY FIGURES ARE CORRECT, THE INCREASE IN OUR NATIONAL SPACE BUDGET HAS BEEN

[2]PROGRAM EVALUATION REVIEW TECHNIQUE

FROM A VALUE OF 30% IN 1959 TO 1960 TO A VALUE OF 85% FOR 1961 TO 1962 TO 35% FOR 1963 TO 1964 (REQUESTED). THESE FIGURES ARE WORTHY OF MUCH THOUGHT.

I WANT TO TOUCH ON THE SUBJECT OF TIME ESTIMATES A BIT MORE AND TO DO THIS I WILL DIVIDE OUR WORK INTO TWO PARTS. FIRST, THOSE PROJECTS IN WHICH ALTHOUGH WE HAVE NOT DONE THEM BEFORE, THERE ARE NO ESSENTIAL ENGINEERING UNKNOWNS. BY THIS I MEAN THE PROJECT IS BASED ON ENGINEERING PRINCIPLES REASONABLY WELL UNDERSTOOD AND NONE OF THE MATERIALS AND STRUCTURES USED IN THE DEVICE WILL BE SUBJECTED TO STRESSES OR CONDITIONS NOT PREVIOUSLY SUCCESSFULLY ENCOUNTERED - STRESSES AND CONDITIONS PRODUCED BY FORCES, BY TEMPERATURE, BY RADIATION. THIS SITUATION IS TRUE WITH PROJECTS SUCH AS MERCURY, TIROS, TELSTAR, AND APOLLO. IN THIS CASE WE CAN SAFELY STATE THAT WE CAN ACCOMPLISH OUR GOAL AND WITHIN THE LIMITS OF THE PREVIOUS DISCUSSION ESTIMATE HOW LONG THE ACCOMPLISHMENT WILL REQUIRE.

BUT THERE IS ALSO THE SECOND CATEGORY - THE CATEGORY IN WHICH ALTHOUGH NO UNKNOWN PRINCIPLES ARE INVOLVED, SUCCESS DOES REQUIRE THAT WE LEARN HOW TO SUBJECT MATERIALS AND STRUCTURES TO CONDITIONS THAT HAVE NOT PREVIOUSLY BEEN SUCCESSFULLY MET IN PRACTICE OR IN THE DEVELOPMENT LABORATORY. IN THIS CASE, TIME ESTIMATES ARE OF LIMITED MEANING AND, IN FACT, MAY BE OF LITTLE SUBSTANCE. A LACK OF RECOGNITION OF THIS FACT (AND NEARLY ALL RESEARCH AND DEVELOPMENT ORGANIZATIONS REFUSE TO RECOGNIZE IT TO GREATER OR LESS DEGREE) IS I THINK RESPONSIBLE FOR MORE INACCURATE PLANNING AND AT TIMES MISAPPLICATION OF EFFORT THAN ANY OTHER FACTOR.

THE APPLICATION OF NUCLEAR ENERGY TO SPACE FLIGHT POWER FALLS INTO THIS UNCERTAIN FIELD BECAUSE OF THE TEMPERATURES AT WHICH THE NUCLEAR REACTOR MUST OPERATE TO GIVE A POWER PLANT SUFFICIENTLY LOW IN WEIGHT TO BE APPLICABLE. IF ONE HESITATES TO GIVE DATES FOR SUCH SOLUTIONS, IT IS NOT A CASE OF BEING UNENTHUSIASTIC. IT IS A MATTER OF ATTEMPTING REALISTIC PLANNING - OF FITTING TOGETHER THE PARTS IN A COMPLICATED AND INTRICATE MOSAIC - OUR NATIONAL SPACE PROGRAM.

-FUTURE PROGRAMS-

CONSIDERING OUR FUTURE PROGRAMS, WITH THE COMPLETION OF THE APOLLO PROJECT, WE WILL HAVE MANNED SPACECRAFT THAT CAN OPERATE IN THE EARTH-LUNAR REGIONS; IN EARTH ORBIT; IN MOON ORBIT, OR AS MOON LANDERS. AND WE WILL NEXT CONSIDER MANNED EARTH ORBITING LABORATORIES, FURTHER LUNAR EXPLORATION, AND MANNED FLIGHTS TO THE PLANETS.

IN DECIDING ON A MANNED EARTH ORBITING LABORATORY, THERE IS NO ESSENTIALLY NEW ENGINEERING INFORMATION REQUIRED. WE WILL BUILD ON THE INFORMATION WE ARE OBTAINING WITH OUR FIRST MANNED ORBITING LABORATORY, MERCURY, AND INFORMATION WE WILL OBTAIN WITH THE MORE ADVANCED GEMINI. WE MUST DECIDE THE SPECIFIC EXPERIMENTS WE WISH TO PERFORM WITH MAN, INSTRUMENTS, AND MACHINE. SHOULD WE HAVE VARIABLE GRAVITY, HOW LONG WILL THE MEN STAY ALOFT, THE EXTENT TO WHICH WE WANT TO FLY TO AND FROM THE CRAFT WHILE IT IS IN ORBIT. WE HAVE A CHOICE OF SPACECRAFT MASS FROM 10 TO 100 TONS DEPENDING ON WHICH SATURN LAUNCH VEHICLE WE USE. THE DECISION WILL BE BASED ON WHAT WE WANT TO ACCOMPLISH IN RELATION TO THE MONIES AVAILABLE.

IN EXTENDING OUR MANNED EXPLORATIONS OF THE MOON BEYOND WHAT WE ACCOMPLISH THRU APOLLO, WE MUST RELATE WHAT WE WANT TO THE SIZE OF EFFORT WE THINK APPROPRIATE. THERE ARE UNKNOWNS HERE. WE NEED CONSIDERABLY MORE INFORMATION ON THE LOGISTIC SUPPORT NEEDED SO THAT MEN CAN WORK EFFECTIVELY UNDER THE UNFRIENDLY ENVIRONMENT EXISTING ON THE MOON. WE HAVE AND ARE ACQUIRING RELATIVE EXPERIENCE IN THE MAINTENANCE OF OUR ANTARCTIC STATIONS AND IN THE CONDUCT OF EXPERIMENTS THERE UNDER CONDITIONS REQUIRING CONTINUOUS AND RIGID LIFE PROTECTION.

ON THE USE OF MANNED CRAFT BEYOND THE MOON, CRAFT IN WHICH MEN FLY TO MARS OR VENUS OR BEYOND, MUCH STUDY AND EXPERIMENTATION ARE REQUIRED. WE BELIEVE SUCH FLIGHTS CAN BE ACHIEVED, BUT WE DO NOT KNOW THE PREFERRED MEANS OF ACCOMPLISHING THEM.

THERE ARE THREE NEW REQUIREMENTS TO BE MET: FIRST, A TRIP TO MARS AND RETURN WILL PROBABLY TAKE ONE TO TWO YEARS. THIS WILL MEAN DEVELOPMENT OF SPACECRAFT IN WHICH MEN CAN LIVE AND OPERATE WITHOUT RESUPPLY OF WATER, FOOD, OR OXYGEN WITH ALL NECESSARY MAINTENANCE OF THE CRAFT ACCOMPLISHED BY THE CREW WITH MATERIEL ABOARD THE CRAFT AT THE START OF THE FLIGHT. THESE, WE BELIEVE, CAN BE ACCOMPLISHED.

SECOND, THE MEN MUST BE PROTECTED FROM THE SUN STORMS THAT SWEEP THROUGH SPACE, STORMS IN THE FORM OF SHOWERS OF INTENSE RADIATION LASTING, NOT LONG, A DAY OR TWO, WITH THE LETHAL DANGER LIMITED TO A FEW HOURS. THESE STORMS PRESUMABLY OCCUR AT MOST TWO OR THREE TIMES A YEAR. WE NEED MORE DATA ON THEIR INTENSITY SO THAT WE CAN DESIGN ADEQUATE SPACECRAFT SHIELDING.

THIRD, TO FLY TO THE PLANETS GREAT CHANGES IN VELOCITY ARE REQUIRED OF THE SPACECRAFT, CHANGES THAT MUST BE EFFECTED BY ROCKETS THAT ARE A PART OF THE SPACECRAFT; CHANGES THAT DEMAND EITHER MANY TIMES THE AMOUNT OF PROPELLANT USED ON EARTH-MOON FLIGHTS, OR REQUIRE MUCH MORE EFFICIENT USE OF THE PROPELLANT.

IT IS IN THIS AREA OF PLANETARY FLIGHT THAT WE LOOK TO NUCLEAR ENERGY TO SUPPLY THE ANSWER. SUCCESS IN OUR DEVELOPMENT OF NUCLEAR ROCKETS AND NUCLEAR ELECTRIC GENERATORS WILL MEAN

MANNED TRIPS TO THE PLANETS WILL BE EASED MANY FOLD.[3] THIS IS WHY OUR NUCLEAR ROCKET AND POWER PROJECTS (ROVER, KIWI, NERVA, SNAP-8, SNAP-50) ARE OF GREAT NATIONAL IMPORTANCE.

IN OUR SPACE SCIENCE PROGRAM, THE KNOWLEDGE THAT WE WILL ACQUIRE WILL CONTINUE TO INCREASE AT AN EXPANDING RATE FOR THIS IS THE NATURE OF SCIENCE.

AGAIN WE MUST DECIDE ON THE MAGNITUDE OF THE EFFORT, AND WHEN I SAY "WE" I MEAN THE NATION AS A WHOLE. THE LARGER LAUNCH VEHICLES, THRU SATURN V, WILL INCREASE MANIFOLD THE OPPORTUNITIES FOR THESE EXPLORATIONS.

IN APPLICATIONS, OUR IMMEDIATE GOALS ARE THE 24 HOUR COMMUNICATIONS SPACECRAFT, COMPLETE METEOROLOGICAL COVERAGE OF THE GLOBE WITH NIMBUS, AND ADVANCES IN THE NAVIGATIONAL AND COMMUNICATIONS PROGRAMS OF THE DEPARTMENT OF DEFENSE.

HOW DECIDE THE EFFORT WE SHALL PUT IN SPACE. I DO NOT THINK ONE CAN ARRIVE AT THE ANSWER BY REASON. REASON GOES ONLY PART WAY. QUOTING FROM RUSSELL[4], "REASON IS A HARMONISING, A CONTROLLING FORCE RATHER THAN A CREATIVE ONE. -- IT IS INSIGHT THAT FIRST ARRIVES AT WHAT IS NEW." CALL IT INSIGHT, JUDGMENT, INTUITION - WHAT YOU WILL - THIS IS THE FACTOR ON WHICH WE ARE DEPENDENT IN MAKING THE MAJOR DECISIONS THAT LEAD TO FUTURE PROGRESS. AND MEN OF HIGH INTELLECT WILL TAKE OPPOSING VIEWS ON THESE QUESTIONS UNTIL EXPERIMENT PROVIDES SPECIFIC ANSWERS AND THEN IT CAN BE TOO LATE TO START.

[3]THERE ARE, OF COURSE, MANY IMPORTANT USES FOR NUCLEAR ROCKETS AND POWER PLANTS IN THE EARTH-MOON REGIONS.

[4]"OUR KNOWLEDGE OF THE EXTERNAL WORLD", BERTRAND RUSSELL

IN SCIENCE AND TECHNOLOGY, THIS LATTER FACTOR WAS NOT TOO IMPORTANT UNTIL THE LAST TWO DECADES. PREVIOUS TO THIS, THE MENTALITY AND ALSO THE RESOURCES REQUIRED TO PROVE REASONABLY WELL A NEW DEVICE, A NEW MODE OF ACTION, COULD BE SUPPLIED BY A FEW MEN WORKING ON THEIR OWN - WATT AND THE STEAM ENGINE, FARADAY AND ELECTRICITY, THE WRIGHT BROTHERS AND THE AIRPLANE, MARCONI AND RADIO. BUT THIS IS NO LONGER TRUE. NOW, BECAUSE OF THE EXPENSE INVOLVED, PROJECTS AS VAST IN CONCEPT AS NUCLEAR ENERGY OR SPACE MUST BE SPONSORED BY THE NATION AS A WHOLE AND THE DECISION TO DO OR NOT TO DO MADE AS A RESULT OF THE CONVICTIONS AND LEADERSHIP OF MEN IN HIGH PLACES. AND THE ABILITY OF THESE MEN TO JUDGE TECHNICAL MATTERS BECOMES OF GREAT IMPORTANCE. THESE FACTORS INEVITABLY PLACE VITAL REQUIREMENTS ON OUR SCIENTISTS AND ENGINEERS TO APPRECIATE THE INDUSTRIAL AND SOCIOLOGICAL EFFECTS THAT WILL RESULT AND RESULT SWIFTLY FROM THEIR ACTIONS.

-SPACE AND NATIONAL SECURITY-

ON CONTRIBUTIONS TO OUR NATIONAL SECURITY, ALL BENEFITS THAT WE HAVE OBTAINED FROM OUR SPACE FLIGHT APPLY DIRECTLY OR INDIRECTLY TO OUR NATIONAL SECURITY. THE BENEFITS FROM WEATHER FORECASTING, BETTER COMMUNICATIONS, BETTER NAVIGATION APPLY DIRECTLY AND IMMEDIATELY. THE BENEFITS, MENTAL AND MORALE, FROM ACCOMPLISHING THINGS OF GREAT DIFFICULTY APPLY DIRECTLY. THE BENEFITS FROM INCREASED SCIENTIFIC KNOWLEDGE APPLY INDIRECTLY, THOSE FROM INCREASED ENGINEERING KNOWLEDGE AND TECHNICAL SKILLS APPLY DIRECTLY.

THE RECENT NASA-DOD GEMINI AGREEMENT SIGNED JOINTLY BY MR. WEBB AND MR. MCNAMARA GOES A LONG WAY TO INSURING THAT THERE WILL BE A CONTINUED AND CLOSE CORRELATION BETWEEN THE SECURITY NEEDS OF OUR NATION AND THE POSSIBILITIES OF REALIZING THESE NEEDS THRU OUR ADVANCES IN SPACE TECHNOLOGY.

IN THIS GENERAL FIELD OF NATIONAL SECURITY, WE MUST REALIZE THAT THE CHARACTERISTICS OF SPACE TRAVEL MEAN THAT WE CANNOT APPLY DIRECTLY TO SPACE FLIGHT THE RULES OF SOVEREIGNTY AS APPLIES TO LAND, SEA, AND AIR.

AMBASSADOR STEVENSON BROUGHT THIS FORCEFULLY TO THE ATTENTION OF THE UNITED NATIONS IN AN ADDRESS HE MADE A LITTLE OVER A YEAR AGO (DECEMBER 4, 1961). HE STATED:

"WE ARE CONDITIONED TO THINK IN TERMS OF NATIONS DEFINED BY FINITE AREAS EXPRESSED IN FINITE MEASUREMENTS -- SUCH CONCEPTS HAVE NO MEANINGFUL APPLICATION TO THE UNEXPLORED, UNBOUNDED --

REACHES OF OUTER SPACE-- WHICH SURROUNDS NO NATION MORE THAN ANY OTHER NATION--AND WHICH IS INNOCENT OF THE IDEA OF NATIONAL SOVEREIGNTY."

SENATOR GORE (DECEMBER 3, 1962) EXPANDED ON THIS POINT. HE STATED TO THE UNITED NATIONS:

"IT IS THE VIEW OF THE UNITED STATES THAT OUTER SPACE SHOULD ONLY BE USED FOR PEACEFUL -- THAT IS NON-AGGRESSIVE AND BENEFICIAL -- PURPOSES. --(BUT) THERE IS NO WORKABLE DIVIDING LINE BETWEEN MILITARY AND NON-MILITARY USES OF SPACE. -- OBSERVATION -- (SPACECRAFT) OBVIOUSLY HAVE MILITARY AS WELL AS SCIENTIFIC AND COMMERCIAL APPLICATIONS. -- WE CANNOT BANISH ALL MILITARY ACTIVITIES IN SPACE UNTIL WE BANISH THEM ON EARTH. --(HOWEVER) EVEN THOUGH IT IS NOW FEASIBLE, THE UNITED STATES HAS NO INTENTION OF PLACING WEAPONS OF MASS DESTRUCTION IN ORBIT UNLESS -- COMPELLED TO DO SO BY -- ACTIONS OF THE SOVIET UNION."

-RELATION TO OUR ECONOMY-

IN RELATION TO OUR NATION'S ECONOMY AND THE DEVELOPMENT OF THIS ECONOMY THE SPACE PROGRAM IS A PART OF THE TECHNOLOGICAL REVOLUTION UNDERWAY SINCE THE START OF WORLD WAR II. THIS REVOLUTION HAS CHANGED EMPHASIS IN THE REQUIREMENTS FOR INDUSTRIAL AND ECONOMIC ADVANCE. AMBASSADOR GALBRAITH HAS, I THINK, EXPRESSED THIS VERY IMPORTANT CHANGE IN CLEAR TERMS:[5]

> "THE CLASSICAL TRINITY OF PRODUCTIVE FACTORS (ARE) LAND--, LABOR--, AND CAPITAL.--- --- ALL PRODUCTION REQUIRES ALL THREE ---. BUT THE IMPORTANCE ATTACHED TO (THEM) HAS CHANGED REMARKABLY---. AT THE BEGINNING OF THE LAST CENTURY--LAND SEEMED PECULIARLY IMPORTANT.--- ---AS THE CENTURY PASSED, CAPITAL RAPIDLY ACHIEVED A POSITION OF DOMINANCE. --- --- THIS EMPHASIS ON CAPITAL WAS REINFORCED BY THE NATURE OF INDUSTRIAL ADVANCE. --- --- IT CONSISTED NOT OF THE INVENTION OF A GREAT NUMBER OF NEW TECHNIQUES BUT THE SPREAD OF A -- SMALL NUMBER OF -- IMPORTANT ONES --- TEXTILE(S)--- --- STEAM POWER--STEEL ---. INVESTMENT IN PHYSICAL CAPITAL IS STILL A PRIME MEASURE OF PROGRESS, BUT -- -- PROGRESS IS COMING TO DEPEND MORE AND MORE ON

[5]ADVENTURES OF THE MIND, EDITED BY RICHARD TRUELSEN AND JOHN KOBLER. ALFRED A. KNOPF, 1961.

THE QUALITY RATHER THAN THE QUANTITY OF --- CAPITAL EQUIPMENT --- --- AND ON THE INTELLIGENCE AND SKILL OF THOSE WHO USE IT. --- --- (AND) IT COMES TO THIS. WE NOW GET THE LARGER PART OF OUR INDUSTRIAL GROWTH NOT FROM --- MORE CAPITAL INVESTMENT BUT FROM IMPROVEMENT IN MEN --- ---."

ACCEPTING THE SPACE CHALLENGE CALLS FOR A GREAT NATIONAL EFFORT IN IMPROVING MEN AND SO IMPROVING THE PRODUCTS PRODUCED BY MEN. MEN CANNOT EFFECTIVELY WORK IN THE FIELD OF SPACE WITHOUT DEVELOPING THEIR INTELLECTUAL CAPABILITIES TO THE LIMIT.

THIS CHANGE IS PARTIALLY EXEMPLIFIED IN A BREAKDOWN OF THE 1964 FISCAL YEAR BUDGET (OBLIGATIONAL AUTHORITY) IN THE AERONAUTICS, MISSILES, AND SPACE FIELDS:

APPROXIMATE REQUESTS FOR FY 1964 IN $BILLIONS

	PROCUREMENT	RESEARCH AND DEVELOPMENT	TOTALS
AIRCRAFT	6.4 (87%)	1.0 (13%)	7.4
MISSILES	4.1 (60%)	3.0 (40%)	7.1
SPACE SYSTEMS	----	7.5 (100%)	7.5
TOTAL	10.5 (47%)	11.5 (53%)	22.5

WE SEE THAT THE TOTAL IS EQUALLY DIVIDED BETWEEN AIRCRAFT, MISSILES, AND SPACE SYSTEMS. (I DO NOT USE THE TERM "AEROSPACE" BECAUSE I THINK IT IS A MISNOMER AND CAN IN FACT BE MISLEADING.) THERE IS A PARTICULARLY SIGNIFICANT DIFFERENCE IN THE DISTRIBUTION OF THE FUNDS WITHIN THE HEADINGS. THE AIRCRAFT INDUSTRY IS GEARED TO A PROCUREMENT PROGRAM (85%). THE MISSILE SECTOR IS ABOUT EVENLY DIVIDED BETWEEN PROCUREMENT AND RESEARCH AND DEVELOPMENT, WHILE THE SPACE FLIGHT EFFORT IS 100% RESEARCH AND DEVELOPMENT. AND

EVEN THOUGH MOST OF THE SPACE FLIGHT MONIES GO INTO HARDWARE FOR THE FLIGHT SYSTEMS, THE SUCCESS OF THE INDIVIDUAL COMPANIES REQUIRES ADAPTATION TO A BUSINESS NOT GEARED TO PROCUREMENT OF MANY COPIES OF A SINGLE SYSTEM.

- RELATION TO EDUCATION -

THIS CHANGE IS ALSO REFLECTED IN OUR EDUCATIONAL REQUIREMENTS AT THE COLLEGE AND UNIVERSITY LEVEL. LET ME REVIEW CERTAIN FACTORS THAT HELP TO EXPLAIN THE SITUATION.

THE AUTOMOBILE WAS DEVELOPED THROUGH THE STAGE OF MASS PRODUCTION FOR THE MOST PART BY MEN WHOSE FORMAL TRAINING HAD NOT GONE BEYOND HIGH SCHOOL. FOR THE PROPELLER DRIVEN AIRCRAFT, MEN AT THE BACHELOR'S LEVEL PLAYED THE DOMINANT PART. WITH THE JET AIRCRAFT DEVELOPMENT WE SEE A MARKED PERCENTAGE OF MEN WITH MASTERS DEGREE. AS WE GO INTO SPACE WE SEE A DOCTORS DEGREE BECOMING EXTREMELY IMPORTANT. THIS HAS HAD TWO RESULTS. FIRST, OF COURSE, IT MEANS THAT AS IN MEDICINE AND LAW AND IN THE BASIC SCIENCES, GRADUATE TRAINING TO THE DOCTORATE LEVEL IS BECOMING A MUST - A MUST IF ONE EXPECTS TO PROGRESS IN THE NEW FRONTIERS OF ENGINEERING.

SECONDLY, AND POSSIBLY OF MORE SIGNIFICANCE BECAUSE OF THE GREATER BASIC KNOWLEDGE REQUIRED TO EFFECTIVELY ENTER ADVANCED ENGINEERING FIELDS, THERE IS A MORE DIRECT ROUTE FOR THE APPLICATION OF BASIC AND APPLIED RESEARCH TO ENGINEERING DEVELOPMENTS AND HARDWARE CONSTRUCTION. THIS ACCELERATES THE IMPACT OF MEN'S SCIENTIFIC AND ENGINEERING ACTIVITIES ON OUR DAILY LIVES - LESS THAN FIVE YEARS AFTER OUR FIRST SPACE FLIGHT WE HAVE A MULTI-BILLION DOLLAR INDUSTRY IN THE MAKING, OVER A HUNDRED SUCCESSFUL SPACECRAFT LAUNCHINGS, METEROLOGICAL SPACECRAFT IN OPERATION, TV SPACECRAFT IN LIMITED OPERATION.

TO MEET THE SPACE CHALLENGE WE MUST SEE TO IT THAT OUR ENGINEERING EDUCATION GOES BEYOND AN EARTH BASED SYSTEM - THAT ENGINEERING

STUDENTS ARE GEARED TO SPACE SYSTEMS AND SPACE TRAJECTORIES - THAT THEY FULLY GRASP THE DIFFERENCES IN THE PROPORTIONS OF THE ENERGY AND MOMENTUM RELATIONSHIPS WHEN WE ARE NO LONGER EARTH BOUND.

WE MUST EFFECT THE EDUCATIONAL CHANGES REQUIRED TO EFFECTIVELY USE THIS VAST NEW CONCEPT - FLIGHT IN SPACE. PLANCK DESCRIBES THE SITUATION CLEARLY:[6]

> "AN IMPORTANT SCIENTIFIC INNOVATION RARELY MAKES ITS WAY BY GRADUALLY WINNING OVER AND CONVERTING ITS OPPONENTS; WHAT DOES HAPPEN IS THAT ITS OPPONENTS DIE OUT --- --- (AND) THE GROWING GENERATION IS FAMILIARIZED WITH THE IDEA FROM THE BEGINNING; ANOTHER INSTANCE OF THE FACT THAT THE FUTURE LIES WITH YOUTH".

WE MUST INSURE THAT THE EDUCATIONAL PEOPLE GIVE THE "GROWING GENERATION" THE OPPORTUNITY TO BE FAMILIARIZED WITH THE VISTAS PROVIDED BY OPERATIONS IN SPACE. THERE IS A PARTICULAR NEED TO BE MET IN THE SMALLER COLLEGES AND UNIVERSITIES THAT DO NOT HAVE THE CATALYST OF EXTENSIVE GOVERNMENT RESEARCH CONTRACTS, BUT ON THE OTHER HAND DO PROVIDE A CLOSE TEACHER-STUDENT RELATIONSHIP.

[6] "THE NEW SCIENCE" BY MAX PLANCK, 1959, MERIDIAN BOOKS, INC.

- CLOSURE -

I HAVE TOUCHED ON MANY SUBJECTS THIS EVENING. I HAVE NOT GIVEN ANSWERS, BUT I HAVE ATTEMPTED TO DIRECT YOUR ATTENTION TO THINGS THAT I THINK ARE IMPORTANT. IN CLOSING I WANT TO QUOTE FROM DE TOCQUEVILLE'S "DEMOCRACY IN AMERICA".

A HUNDRED AND THIRTY YEARS AGO THIS YOUNG FRENCHMAN VISITED THE UNITED STATES. WHEN HE RETURNED TO FRANCE HE WROTE OF WHAT HE LEARNED AND OF HIS IMPRESSIONS OF THIS FEDERATION OF TWENTY-FOUR STATES AND 13,000,000 PEOPLE.[7]

HE WROTE:

> "THE TIME WILL COME WHEN ONE HUNDRED AND FIFTY MILLION PEOPLE WILL BE LIVING IN NORTH AMERICAN, EQUAL IN CONDITIONS, --- --- OWING THEIR ORIGIN TO THE SAME CAUSE, AND PRESERVING --- --- THE SAME LANGUAGE --- --- AND IMBUED WITH THE SAME OPINIONS --- --- THIS IS CERTAIN; AND IT IS A FACT NEW TO THE WORLD - A FACT FRAUGHT WITH --- PORTENTOUS CONSEQUENCES --- ---."

AND HE CONTINUES:

> "THERE ARE TWO GREAT NATIONS IN THE WORLD AND WHILST THE ATTENTION OF MANKIND WAS DIRECTED ELSEWHERE, THEY HAVE SUDDENLY ASSUMED A MOST PROMINENT PLACE AMONGST THE NATIONS: --- --- I ALLUDE TO THE RUSSIANS AND THE AMERICANS. --- --- THE (AMERICAN) GIVES FREE SCOPE TO THE UNGUIDED EXERTIONS AND COMMON-SENSE OF THE CITIZENS; THE RUSSIAN CENTRES ALL AUTHORITY ---

[7] ALEXIS DE TOCQUEVILLE, DEMOCRACY IN AMERICA

--- IN A SINGLE ARM; THE PRINCIPLE INSTRUMENT OF THE FORMER IS FREEDOM; OF THE LATTER SERVITUDE. THEIR STARTING POINT IS DIFFERENT, AND THEIR COURSES ARE NOT THE SAME; YET EACH --- --- SEEMS TO BE MARKED --- --- TO SWAY THE DESTINIES OF HALF THE GLOBE."

WE NEED NOT CHANGE THIS STATEMENT OTHER THAN TO SAY "TO SWAY THE DESTINIES OF ALL THE GLOBE."

CURRENTLY ONLY RUSSIA AND THE UNITED STATES CAN AFFORD THE MAGNITUDE OF EFFORT REQUIRED TO FULLY UTILIZE SPACE. AND SURELY THIS IS "A FACT FRAUGHT WITH PORTENTOUS CONSEQUENCES" FOR "THE FRONTIER --- (THAT SPACE) OPENS FOR HUMAN ADVANCEMENT EXCEEDS ANY MAN HAS FACED."

IT IS UP TO US IN THE SPACE BUSINESS TO UNDERSTAND TO THE LIMIT OF OUR ABILITIES THE VASTNESS OF THE OPPORTUNITIES OPENED TO US THRU FLIGHT INTO SPACE AND TO FEEL DEEPLY THE TRUST PLACED IN US BY THE PEOPLE OF THE NATION; A TRUST EXPRESSED BY THE MAGNITUDE OF THE SPACE PROGRAM THEIR ELECTED REPRESENTATIVES ARE MAKING POSSIBLE. I PRESUME IT IS BECAUSE AS A NATION WE RECOGNIZE THE IMPORTANCE OF THESE THINGS THAT WE HAVE DECIDED THROUGH OUR ELECTED REPRESENTATIVES TO ACHIEVE THESE VAST SPACE OBJECTIVES. SO

"WE SET SAIL ON THIS NEW SEA --- THERE IS NEW KNOWLEDGE TO BE GAINED -- NEW RIGHTS TO BE WON AND THEY MUST BE WON AND USED FOR THE PROGRESS OF ALL PEOPLE."[8]

[8]-PRESIDENT KENNEDY'S ADDRESS AT RICE UNIVERSITY, HOUSTON, TEXAS, SEPTEMBER 13, 1962